INVESTIGATION OF IRON ORES AND LIMESTONES FROM MESSRS. LYON, SHORB & CO'S IRON ORE BANKS ON SPRUCE CREEK, HALF MOON RUN AND WARRIOR'S MARK RUN, IN CENTRE, BLAIR AND HUNTINGDON COUNTIES, PA.

By F. A. Genth.

(*Read before the American Philosophical Society, February 6th*, 1874.)

NO. 1. EAST PENNINGTON BANK.

The greater portion of thirteen specimens, received for examination, was compact, dull, of various shades of brown and had like No. 1 an admixture of dark brown pitchy ore; other portions were porous and had the cavities lined with botryoidal fibrous brown limonite, others were stalactitic. Some of the ore had lost a part of its water of hydration and had changed into turgite and even into hematite. Many of the pieces showed a considerable admixture of manganese minerals, such as wad, minute quantities of pyrolusite and perhaps psilomelane, some contained a large quantity of rounded grains of quartz.

An average of the whole showed the following composition:

Ferric oxide	=	65.88	=	44.77 Metallic Iron.
Manganic oxide	=	6.00	=	4.18 Metallic Manganese.
Cobaltic "		0.34		
Alumina		trace		
Magnesia		0.26		
Lime		trace		
Phosphoric acid		0.22	=	0.097 Phosphorus.
Silicic acid		6.38		
Quartz		7.87		
Water		13.05		
		100.00		

100 Iron and Manganese contain 0.197 Phosphorus.

NO. 2. WEST PENNINGTON BANK.

Five specimens were submitted for examination. The ore was mostly of various shades of yellowish brown to dark hair-brown and without lustre; in some was an admixture of a dark blackish brown ore with subconchoidal fracture and a resinous lustre; some portions had a slight waxy lustre, others were earthy and dull. It was amorphous, but in places the cavities were lined with a coating of brown fibrous limonite. On being breathed upon, it developed a strong argillaceous odor.

An average of the five specimens contained :

Ferric oxide	=	70.93	=	49.65 Metallic Iron.
Manganic oxide	=	0.38		
Cobaltic "		trace		
Alumina		2.81		
Magnesia		0.14		
Lime		0.08		
Phosphoric acid		0.37	=	0.16 Phosphorus.
Silicic acid		4.38		
Quartz		7.91		
Water		13.00		
		100.00		

100 Iron contain 0.32 Phosphorus.

No. 6. Rumbarger Bank.

A sample of ore was taken from a pile alongside of the Bank. It is mostly amorphous and compact, also somewhat porous, and has the cavities lined with a thin coating of fibrous limonite ; the cavities are also coated with red ochre and at times with yellow ochre.

The composition was found to be as follows :

Ferric oxide	=	74.16	=	51.91 Metallic Iron.
Manganic oxide		trace		
Alumina		3.06		
Magnesia		0.24		
Lime		trace		
Phosphoric acid		0.36	=	0.158 Phosphorus.
Silicic acid		6.11		
Quartz		3.94		
Water		12.13		
		100.00		

100 Iron contain 0.30 Phosphorus.

No. 11. Lytle Bank.

The sample received for examination consisted mainly of amorphous compact brown ore, intermixed with fine fibrous limonite. The fibres are from $\frac{1}{4}$ to $\frac{1}{2}$ of an inch in length and form botryoidal coatings ; sometimes divergent. The outside covered with yellowish ochreous ore.

The analysis gave :

Ferric oxide	=	82.00	=	57.40 Metallic Iron.
Manganic oxide	=	trace		
Alumina	=	1.94		
Magnesia		0.17		
Lime		trace		

Phosphoric acid		0.37	=	0.16 Phosphorus.
Silicic acid		2.98		
Quartz	=	0.44		
Water	=	12.10		
		100.00		

100 Iron contain 0.278 Phosphorus.

No. 14. Bull Bank.

The samples for investigation, five in number, were taken from piles of ore taken out about thirty years ago. One consisted of a beautiful fibrous limonite of a pale hair-brown color and silky lustre, much resembling that from the Lytle Bank, but of fibres two inches in length. The others represented the amorphous ores. They are compact, of various shades of brown, without lustre; they contain more or less cavities, partly filled with ochreous ore of a yellowish or reddish color. The amorphous ores have, on being breathed upon, a strong argillaceous odor.

a. Pure Fibrous Limonite.

Ferric oxide	=	81.48	=	57.04 Metallic Iron
Manganic oxide	=	0.07		
Alumina	=	0.49		
Magnesia, Lime		traces.		
Phosphoric acid		0.08	=	0.035 Phosphorus.
Silicic acid		3.98		
Water		13.90		
		100.00		

100 Iron contained 0.061 Phosphorus.

b. Average of the five Samples.

Ferric oxide	=	74.85	=	52.40 Metallic Iron.
Manganic oxide	=	0.29		
Cobaltic oxide		0.21		
Alumina		2.42		
Magnesia		0.12		
Lime		trace.		
Phosphoric acid		0.24	=	0.105 Phosphorus.
Silicic acid		4.15		
Quartz		5.92		
Water		11.80		
		100.00		

100 Iron contained 0.20 Phosphorus.

No. 15. Pond Bank No. 1.

Two of the four specimens received were of a dark brown porous amorphous ore with very little lustre, more or less mixed with yellowish and reddish ochreous ore; the third piece was of a paler brown and contained small quantities of fibrous ore, the fourth was an ochreous ore of a pale brown and yellowish color. An average of the four samples contained:

Ferric oxide	=	78.68	=	55.08 Metallic Iron.
Manganic oxide	=	0.42		
Cobaltic "		trace.		
Alumina		2.89		
Magnesia		0.20		
Lime		trace.		
Phosphoric acid		0.16	=	0.07 Phosphorus.
Silicic acid		3.17		
Quartz		1.71		
Water		12.77		
		100.00		

100 Iron contain 0.127 Phosphorus.

No. 16. Red Bank No. 1.

Five samples of ore received. It is generally an amorphous compact ore, with a considerable admixture of sand. Some is more porous, and has the cavities lined with fibrous limonite, and more or less filled with clay. Emits, when breathed upon, a strong argillaceous odor. Part of the specimens had lost a portion of their water of hydration.

The analysis of an average sample gave:

Ferric oxide	=	65.44	=	45.81 Metallic Iron.
Manganic oxide	=	0.13		
Cobaltic oxide		trace		
Alumina		5.31		
Magnesia		0.16		
Lime		trace		
Phosphoric acid	=	0.21	=	0.09 Phosphorus.
Silicic acid		6.76		
Quartz		12.78		
Water		9.21		
		100.00.		

100 Iron contain 0.195 Phosphorus.

No. 19. Whorell Bank.

Two pieces of a fine brown porous amorphous ore of various shades, between yellowish and dark-brown; some portions showing a slight pitchy lustre; the greater part is dull. Has a strong argillaceous odor when breathed upon.

The analysis of an average sample gave:

Ferric oxide	=	69.71	=	48.80 Metallic Iron.
Manganic oxide		0.46		
Cobaltic oxide		trace		
Alumina		3.37		
Magnesia		0.08		
Lime		trace		
Phosphoric acid	=	0.97	=	0.43 Phosphorus.
Silicic acid		3.51		
Quartz		9.60		
Water		12.30		
		100.00		

100 Iron contain 0.87 Phosphorus.

No. 21. Wrye Bank.

Five specimens received. The ore is amorphous, porous, and scoriaceous. Some of the cavities are lined with a thin coating of fibrous ore. The more compact pieces contain a large admixture of rounded quartz grains.

An analysis of an average sample gave:

Ferric oxide	=	77.00	=	53.90 Metallic Iron.
Manganic oxide		0.36		
Cobaltic oxide		trace		
Alumina		2.15		
Magnesia		0.14		
Lime		0.15		
Phosphoric acid		0.19	=	0.08 Phosphorus.
Silicic acid		2.60		
Quartz		5.53		
Water		11.88		
		100.00		

100 Iron contain 0.15 Phosphorus.

No. 24. Dry Hollow Bank.

Amongst the eight specimens received for examination was one of a beautiful variety of fibrous limonite; the fibres are of about one inch in

length, also divergent and radiating; color dark brown, lustre silky; the other ores were both compact and porous amorphous brown limonites, some with the cavities lined with fibrous ore, others having them filled with ochreous clayish ores. Some of the pieces give a strong argillaceous odor, when breathed upon.

a. Pure Fibrous Limonite.

Ferric oxide	=	83.13	=	58.19 Metallic Iron.
Manganic oxide	=	0.15		
Alumina	=	0.74		
Magnesia		0.09		
Lime		trace		
Phosphoric acid		0.50	=	0.22 Phosphorus
Silicic acid		2.47		
Water		12.92		
		100.00		

100 Iron contain 0.37 Phosphorus.

b. Average of the eight Specimens.

Ferric oxide	=	75.90	=	53.13 Metallic Iron.
Manganic oxide	=	0.16		
Cobaltic oxide	=	trace		
Alumina	=	2.44		
Magnesia		0.20		
Lime		trace.		
Phosphoric acid		0.54	=	0.24 Phosphorus.
Silicic acid		2.74		
Quartz	=	7.84		
Water		10.18		
		100.00		

100 Iron contain 0.45 Phosphorus.

No. 24. *b.* Red Bank of Dry Hollow.

An examination of six specimens, showed the general character of the ore to be amorphous, of a dark brown color, and compact; some pieces have cavities lined with yellowish brown and dark brown fibrous limonite; others have rounded quartz grains disseminated through the mass. A portion of the ores has lost part of the water of hydration. The cavities and fractures are frequently coated or filled with a brownish red ochreous ore.

An average sample of the whole contained:

Ferric oxide	=	80.34	=	56.24 Metallic Iron.
Manganic oxide		0.52		

Cobaltic oxide	trace		
Alumina	1.66		
Magnesia	0.13		
Lime	trace		
Phosphoric acid	0.49	=	0.215 Phosphorus.
Silicic acid	3.18		
Quartz	2.63		
Water	11.05		
	100.00		

100 Iron contain 0.38 Phosphorus.

No. 27. Kerr and Bredin Bank.

The three specimens received show the ore to be mostly amorphous and compact, and of various shades of brown, also earthy; some parts are porous and the cavities lined with fibrous limonite, sometimes in botryoidal forms. On being breathed upon, developes a strong argillaceous odor.

The average of the samples contained :

Ferric oxide	=	70.67	=	49.47 Metallic Iron.
Manganic oxide		0.36		
Cobaltic oxide		trace		
Alumina		3.91		
Magnesia		0.26		
Lime		trace		
Phosphoric acid	=	0.19	=	0.08 Phosphorus.
Silicic acid		5.48		
Quartz		6.80		
Water		12.33		
		100.00		

100 Iron contain 0.16 Phosphorus.

No. 28. Hostler Bank.

One specimen of so-called "Pipe Ore." Amorphous, compact and earthy, brown to yellowish brown. Porous. Stalactitic. Coated with yellowish and reddish ochreous ore.

The analysis gave :

Ferric oxide	=	78.58	=	55.01 Metallic Iron.
Manganic oxide		0.08		
Alumina		0.88		
Magnesia		0.54		
Lime		0.30		
Phosphoric acid		0.36	=	0.158 Phosphorus.

Silicic acid		4.25
Quartz	=	2.60
Water	=	12.41
		100.00

100 Iron contain 0.28 Phosphorus.

No. 29. Pennsylvania Bank.

a. Two samples received for examination.

Amorphous brown compact ore mixed with ochreous yellowish or reddish ore; Porous, some of the cavities lined with a very fine coating of fibrous ore.

b. So-called Pipe ore.

Amorphous porous ore, in columnar masses, the cavities filled with ferruginous clay.

c. Quartz grains, cemented by brown amorphous limonite, and disseminated through it, patches of hydrous manganic oxide and perhaps of psilomelane.

a. Average of two Samples.

Ferric oxide	=	81.55	=	57.10 Metallic Iron.
Manganic oxide		0.10		
Cobaltic oxide		trace		
Alumina		1.49		
Magnesia		0.47		
Lime		trace		
Phosphoric acid		0.16	=	0.07 Phosphorus.
Silicic acid		2.98		
Quartz		1.55		
Water		11.70		
		100.00		

100 Iron contain 0.12 Phosphorus.

b. Pipe Ore.

Ferric oxide	=	83.74	=	58.62 Metallic Iron.
Manganic oxide	=	0.31		
Cobaltic oxide		trace		
Alumina		0.33		
Magnesia		0.34		
Lime		trace		
Phosphoric acid		0.14	=	0.06 Phosphorus.
Silicic acid		2.57		
Quartz		0.44		
Water		12.13		
		100.00		

100 Iron contain 0.10 Phosphorus.

c. Sandrock.

Ferric oxide	=	43.65	=	30.56 Metallic Iron.
Manganic oxide } Cobaltic oxide }		1.55		
Alumina		2.43		
Magnesia		1.64		
Lime		0.12		
Phosphoric acid		0.27	=	0.12 Phosphorus.
Silicic acid		5.19		
Quartz		36.52		
Water		8.63		
		100.00		

100 Iron contain 0.39 Phosphorus.

OLD CUT NORTH OF GATESBURG. *

A peculiar looking amorphous ore, of a brown and yellowish-brown color, uneven to subconchoidal fracture, dull or of slight waxy lustre, inclining to resinous. It has a strong argillaceous odor when breathed upon.

The composition of the one specimen, which I received for examination, was found to be :

Ferric oxide	=	71.63	=	50.14 Metallic Iron.
Manganic oxide } Cobaltic oxide }	=	0.53		
Alumina		4.63		
Magnesia		0.37		
Lime		trace		
Phosphoric acid	=	1.67	=	0.73 Phosphorus.
Silicic acid		3.69		
Quartz		4.64		
Water		12.84		
		100.00		

100 Iron contain 1.43 Phosphorus.

The amount of metallic iron in the calcined ores is as follows :

No. 1.	East Pennington Bank	51.49	per cent.
" 2.	West Pennington Bank	57.07	"
" 6.	Rumbarger Bank	59.08	"
" 11.	Lytle Bank	65.30	"
" 14.	Bull Bank—*a*, fibrous ore	66.25	"
" "	" " —*b*, average	59.41	"

*Mr. Platt's Station 568.

No. 15.	Pond Bank, No. 1	63.14 per cent.
" 16.	Red Bank, No. 1	50.46 "
" 19.	Whorell Bank	55.64 "
" 21.	Rye Bank	61.17 "
" 24.	Dry Hollow Bank—*a*, fibrous ore	66.82 "
" "	" " " —*b*, average	59.15 "
" 24*b*.	Red Bank of Dry Hollow	63.23 "
" 27.	Kerr and Bredin Bank	56.43 "
" 28.	Hostler Bank	62.80 "
" 29.	Pennsylvania Bank—*a*, average	64.67 "
" "	" " —*b*, pipe ore	66.71 "
" "	" " —*c*, sandrock	33.44 "
Ore from Old Cut N. of Gatesburg		57.52 "

All these ores were examined for Sulphur and Sulphuric acid, but not a single one gave a decided reaction for either. They were also examined for Titanium, Chromium, Vanadium, and other metals, but with negative results.

Their only constituent, which has an injurious effect upon the quality of the iron, produced from the same, is phosphoric acid; most of them, however, contain it in too small a quantity to be of much harm. Only two of the samples contain it in a larger proportion.

For better comparison, I will arrange the amounts of Phosphorus which would be contained in 100 parts of iron, provided no loss of either would be sustained:

Fibrous ore of Bull Bank	0.06 Phosphorus.
Pipe ore of Pennsylvania Bank	0.10 "
Average ore of " "	0.12 "
Pond Bank, No. 1	0.127 "
Wrye Bank	0.15 "
Kerr and Bredin Bank	0.16 "
Red Bank No. 1	0.195 "
N. E. or Upper Pennington Bank	0.197 "
Average of Bull Bank	0.20 "
Lytle Bank	0.278 "
Hostler Bank	0.28 "
Rumbarger Bank	0.30 "
S. W. or Lower Pennington Bank	0.32 "
Fibrous ore of Dry Hollow Bank	0.37 "
Red Bank of Dry Hollow	0.38 "
Sandrock of Pennsylvania Bank	0.39 "
Dry Hollow Bank	0.45 "
Whorell Bank	0.87 "
Old cut N. of Gatesburg	1.43 "

Of all the ores submitted for examination only two appeared to be in a

sufficient state of purity to throw light upon their constitution, as they were crystalline, and free from visible impurities. For this reason they were examined separately.

Taking into consideration only their principal constituents, viz : Ferric oxide, Silicic acid and water, the question arises, in which form the silicic acid is present, as it is undoubtedly in chemical combination with the ferric oxide and *not* in the form of a mechanical admixture of sand. If pieces of these fibrous limonites are placed into strong chlorhydric acid, all the ferric oxide will be extracted, and the silicic acid will remain in the shape of the original pieces, of a snow-white color and fibrous structure. The only hydrous ferric silicates, which are known, are Anthosiderite and Degeroeite. The former is a crystalized mineral, which has a composition, represented by the formula $2Fe_2O_3$, $9SiO_2+2H_2O$. It is very probable that, although observed in its pure state only at one locality, it occurs frequently as an admixture with other iron ores.—If we calculate for the 3.98 per cent. of silicic acid in the fibrous mineral from Bull Mine, the requisite quantities of ferric oxide and water, we find 2.36 per cent. of ferric oxide and 0.26 per cent. of water, making an admixture of 6.60 per cent. of anthosiderite. The atomic ratio between the remaining 79.12 per cent. of ferric oxide and 13.64 per cent. of water is 1 : 1.53 or very near 2 : 3, showing the hydrous ferric oxide to be limonite $= 2\ Fe_2\ O_3,\ 3\ H_2\ O$.

If in the same manner we examine into the composition of the fibrous mineral from the Dry Hollow, the 2.47 silicic acid require 1.46 per cent. ferric oxide and 0.17 water, giving an admixture of 4.10 per cent. of anthosiderite.—The atomic ratio between the remaining 81.67 per cent of ferric oxide and 12.75 per cent. of water is 1: 1.4, which also shows the ferric hydrate to be limonite, which, however, has already lost a small part of its water.

The above analyses show besides the mechanically admixed rounded grains of sand, which I distinguish as "quartz," a considerable quantity of silicic acid, which is in chemical combination, probably as a hydrous ferric oxide. But as it is impossible to say what the true character of this mineral may be, whether anthosiderite, or degeroeite a silicate of the composition $Fe_2\ O_3$, $2SiO_2+3H_2O$ or a species not yet known in its pure state, suffice it to say that all these ores are mechanical mixtures of limonite with hydrous ferric silicate and minute quantities of hydrous ferric phosphate, perhaps dufrenite or cacoxenite; some of the ores contain besides these, small quantities of manganese ores, mostly the so-called "bog-manganese" or wad, but also pyrolusite and psilomelane.

It is a very remarkable fact that, although these iron ores are to a great extent at least, the result of the decomposition of limestones and by them precipitated, that almost the entire amount of lime has been washed out of them and only traces are remaining ; of the second constituent of the limestones, the magnesia, a somewhat larger quantity is left behind, owing undoubtedly to the lesser solubility of its carbonate in carbonic acid water.

Of the limestones only a few typical varieties have been more fully investigated, especially those from the Hostler and Pennsylvania Banks.

Limestone at head of Hostler Bank.

It has a fine crystalline granular structure and is mottled, whitish and grey ; the surface is coated with ochreous argillaceous iron ore.

A pure specimen from which the iron had been carefully removed, contained :

Carbonate of Iron	= 0.80	=	0.39 Metallic iron.
" " Manganese	= 0.19	=	
" " Magnesia	= 35.19	=	16.76 Magnesia.
" " Lime	= 59.44	=	33.28 Lime.
Quartz and Silicic Acid	3.84		
Alumina	0.54		
	100.00		

The atomic ratio between Magnesia and Lime is 1: 1.4, which is the composition of some of the "pearlspar" varieties of dolomite.

Limestone in Hostler Bank.

It lies four feet thick over 33 feet of pipeore. It has an ash-grey color and a very fine grain, which is hardly perceptible to the naked eye ; very friable. Its composition was found to be :

Carbonate of Iron	= 0.50	=	0.24 Metallic Iron.
" " Manganese	= 0.24		
" " Magnesia	= 42.52	=	20.25 Magnesia.
" " Lime	= 51.82	=	29.02 Lime.
Quartz and Silicic Acid	4.33		
Alumina	0.42		
Water	0.17		
	100.00		

The atomic ratio between Magnesia and Lime is 1: 1, which shows it to be a true dolomite.

Upper Limestone from Pennsylvania Bank.

Dark grey compact, slightly crystalline.

The analysis gave the following results :

Carbonate of Iron	= 1.31	=	0.63 Metallic Iron.
" " Manganese	= 0.18		
" " Magnesia	3.98	=	1.90 Magnesia.
" " Lime	72.67	=	40.69 Lime.
Quartz and Silicic Acid	18.05		
Alumina	3.81		
	100.00		

The atomic ratio between magnesia and lime is 1 : 15.

Limestone in the Pennsylvania Bank.

Pale ash grey, very finely crystalline, rough to the touch like rotten stone, very friable and easily falling to powder.

Its composition was found to be:

Carbonate of Iron	= 0.45	= 0.22	Metallic Iron.
" " Manganese	= 0.06		
" " Magnesia	42.39	= 20.19	Magnesia.
" " Lime	51.25	= 28.70	Lime.
Quartz and Silicic Acid	5.03		
Alumina	0.82		
	100.00		

The atomic ratio between Magnesia and Lime=1 : 1, shows it to be a true dolomite.

Another Variety of Limestone in the Pennsylvania Bank.

Yellowish grey, soft, rotten, feels rough to the touch, sandy; crystalline; has a laminated structure. Its analysis gave:

Carbonate of Iron	= 1.18	= 0.57	Metallic Iron.
" " Manganese	trace		
" " Magnesia	35.51	= 16.91	
" " Lime	45.73	= 25.61	
Quartz and Silicic Acid	15.83		
Alumina	1.75		
	100.00		

The atomic ratio between Magnesia and Lime=1 : 1.08 proves it also to be a true dolomite.

It is remarkable that the limestones and dolomites, of which I give the analyses, contain almost the entire amount of silicic acid as quartz, only a small quantity is present as soluble silicic acid and in combination with alumina. If the limestones and dolomites are dissolved in acid, the quartz remains often as a scoriaceous mass or in irregular sandy but not rounded or water-worn grains; sometimes it forms large coherent slaty masses in the limestone, frequently filled with minute cavities, previously occupied by rhombohedral crystals of dolomite. Similar pieces found in the Pennsylvania Bank are white, like porcelain and show the same cavities of rhombohedral crystals. Other varieties of limestone in the Pennsylvania Bank have a still greater admixture of quartz and are a real calciferous sand rock.*

University of Pennsylvania, January 23d, 1874.

* These analyses summed up about 100, most of them a little above, one or two a little below, but all within the limits of unavoidable error; for better comparison I thought it advisable to calculate them for 100.00, from the actual result obtained. (F. A. Genth.)

ANALYSES* OF PENNSYLVANIA PIPE, AND PENNINGTON ORE.

3, DEVONSHIRE TERRACE, KENSINGTON, LONDON, W.,
January 5*th*, 1871.

DEAR SIR:—Herewith I beg to forward you the results of my analysis of the two samples of ore, marked, respectively, "Pipe Ore" and "Pennington Bank."

The whole of the samples were intimately pulverized together in each case; they contain

	PIPE ORE.	PENNINGTON BANK.
Silica	10.84	5.42
Peroxide of Iron	73.18	79.05
Protoxide of Iron	.75	
Aluminia	2.51	1.29
Oxide of Manganese	traces.	.11
Carbonate of Lime	.20	
Carbonate of Magnesia	1.20	Magnesia. .11
Phosphoric Acid	.17	.04
Combined Water	9.09	10.57
Moisture	1.81	3.55
Sulphur	.05	
	99.80	100.14
Metallic Iron	51.81	55.34
" " exclusive of Water	58.25	64.35

Both these samples are rich iron ores, sample "Pennington Bank" being nearly pure brown hematite. The pipe ore is a harder ore than "Pennington Bank" ore.

I consider both samples of ore adapted for the manufacture of Bessemer Pig.

Believe me to remain, yours, very faithfully,

EDWARD RILEY, F. C. S.,
Metallurgist, Analytical and Consulting Chemist.

ANALYSIS OF "PIPE ORE," "KERR & BREDIN" AND PENNINGTON BANK ORES, BY CH. ALDENDORF, SUB-DIRECTOR OF THE GEORGE-MARIEN HUTTE HIGH FURNACES, MARCH 9, 1872.

	PIPE ORE.	KERR & BREDIN.	PENNINGTON.
Water	11.190	10.540	12.340
Insoluble Residue, $\left.\begin{matrix}SiO^2\\Al^2O^3\end{matrix}\right\}$	5.120	13.400	5.450
Oxide of Iron, F^2O^3	82.050	73.560	79.450

* These analyses by an English chemist of well known reputation, especially entrusted by Mr. Bessemer with his numerous and important analyses, are here added for comparison.

		PIPE ORE.	KERR & BREDIN.	PENNINGTON.
Alumina,	Al^2O^3.....	1.650	2.840	3.096
Oxide Manganese,	Mn^2O^3....	0.270	0.190	0.440
Chalk,	CaO.....	0.370	0.460	0.440
Magnesia,	MgO.....	trace.	trace.	trace.
Phos. Acid,	$P.O^5$.....	0.080	0.280	0.064
Sulphuric Acid,	$S.O.^3$.....	trace.	trace.	trace.
		100.730	101.270	101.280
Per cent. Metallic Iron.....		57.435	51.492	55.61
Phosphorus in 100 Iron.....		0.061	0.238	0.053
Per ct. Iron, excluding Water,		64.150	56.075	62.540

"The Pipe and Pennington Ores if melted together would make a very superior Bessemer Iron. The Kerr & Bredin *alone* an inferior Bessemer Iron. A separate analysis, however, of Kerr & Bredin shows that its Phosphorus is concentrated in the Clay thereto attached, and it may be that this Ore may be made available for Bessemer Pig, by proper treatment before smelting."

Analysis of Pennsylvania Furnace Limestone by Otto Wuth, Chemist, Pittsburgh, Pa.

From Quarry near the Furnace—a grey crystaline Stone :

Silicic Acid	5.08
Alumina	1.34
Carbonate of Iron	.69
" " Lime	91.53
" " Magnesia	1.31
Sulphate of Lime	trace.
Organic Matter	.05

From Ore Bank Rail Road Cut — a partly crystalline drab-colored stone :

Silicic Acid	4.93
Alumina	.24
Carbonate of Iron	.87
" " Lime	84.66
" " Magnesia	8.98
Sulphate of Lime	.11
Organic Matter	.21

Gray Crystalline Stone, south side of road from Half Moon Run to Hostler Bank, near the Half Moon Run.

Silicic Acid	2.71
Alumina	.11
Carbonate of Iron	1.80
" " Lime	83.91
" " Magnesia	11.14
Sulphate of Lime	.12
Organic Matter	.21

Smooth Grey Stone from north side of road near the foregoing:

Silicic Acid	6.87
Alumina	1.35
Carbonate of Iron	.75
" " Lime	86.42
" " Magnesia	4.24
Sulphate of Lime	.21
Organic Matter	.16

Mining Methods.

It will be seen from the above descriptions, that mining operations have been mostly carried on in this region in an irregular and primitive style. I requested Mr. John W. Harden to give me the benefit of his large and varied experience as a mining engineer and superintendent, both in the English and in the American collieries and iron mines, in stating what ought to be the most economical mode of entering on and exhausting the Nittany Valley limestone deposits. His recent success in increasing the export of limonite from Pinegrove Furnace banks south of Carlisle, by a judicious application of a system of regular approaches, justifies me in placing a high value on any practical suggestions he has to offer respecting similar deposits.

He therefore visited the Pennington, Dry Hollow, Kerr & Bredin, Pennsylvania Furnace, and other Banks above described; and the following extracts from his report will show that there is but one conclusion to arrive at, and that a very simple one; viz., that the system to be almost universally adopted is that by open-cuts, approached from the direction of the railway, at the lowest possible levels, and worked to the right and left, in advancing slopes, one above the other; that the deep rich-ores should be worked at the same time with the upper wash-ores, or not greatly in arrear of them, so that the wash-ore thus won may pay the expenses of uncovering the richer lower ores; and that where surface water is scarce, bore-holes should be sunk to serve the double purpose of exploration and water supply.

Whether additional and larger furnaces be erected in the Valley, or whether the ores be sent by rail to the Iron Works in Eastern and